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Walleye (*Stizostedion vitreum*) utilization and reproductive success on habitat enhancement sites within the Whiteshell Provincial Park, 1987

Stepaniuk, J.R. 1989

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ABSTRACT

A field assessment of walleye spawning improvement projects at Falcon Creek, Hamilton's Creek, Rainbow Falls, Rennie River and Red Rock Lake was undertaken in April and May, 1987. The assessment was based on visual observations of adult walleye during the spawning period, egg collections at the improvement sites and larval drift catches. Visual observations and egg sampling indicated walleye spawning activity on the improvement sites at Falcon Creek, Hamilton's Creek, Rainbow Falls and Rennie River. Viability was significantly greater for eggs incubating on the placed cobble than on the silt and soil substrate. Egg sampling at Red Rock Lake suggested walleye did not utilize the artificial spawning reef, although eggs were collected adjacent to the reef. Walleye larvae were captured downstream of the improvement locations at Hamilton's Creek, Rainbow Falls and Rennie River. Low discharges in April and May, 1987 appeared to reduce spawning and incubation success, particularly at Falcon Creek, Hamilton's Creek and Rennie River.

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INTRODUCTION

Major opportunities for improving walleye numbers lie in maintaining, protecting, and improving the stream habitat essential for walleye production. Walleye show a strong homing instinct, returning annually to a particular spawning site (Machniak 1975). In 1977, Gibson and Hughes, found that walleye could be encouraged to spawn on a preferred gravel substrate if it occurred along their migration route. Walleye reproduction success then might possibly be enhanced by the addition of a suitable substrate in spawning areas where substrate may have previously been limited. Enhancement techniques typically focus on streams less than 4.5 m in width, which frequently offer the greatest potential for enhancement (O.M.N.R. no date). The advantage of stream rather than lake improvement is the overall control of the spawning environment that can be obtained. In particular, water depth, flow, and velocity can occasionally be regulated. Also, addition of substrate and monitoring are much simpler. Other factors considered in stream enhancement projects include gradient, head water storage, depth of flow, existing spawning runs, obstructions to migration, substrate, proximity of spawning areas to the downstream water body, and access of heavy equipment.

Under the Manitoba Habitat Heritage Program, the Manitoba Fisheries Branch has been involved in habitat enhancement for walleye, Stizostedion v. vitreum, since 1984. In the Whiteshell Park, projects have been undertaken to upgrade spawning habitat by placing artificial substrate in known spawning areas as identified by McGarry (1985). In 1984-85 approximately 615m^3 of 7.5-10.0 cm cobble was placed at

known walleye spawning areas in Falcon Creek, Hamilton's Creek, Rennie River, Rainbow Falls (Whiteshell River), and Red Rock Lake. The utilization of these spawning areas by walleye, and their spawning success was unknown. Thus, a study was initiated to evaluate walleye utilization and reproductive success on the artificial substrate at several locations in the Whiteshell Provincial Park in the spring of 1987. In addition, the study was to determine the relationship, if any, between egg distribution and habitat parameters on Hamilton's Creek, and to establish a morphological key distinguishing structural characteristics between larval walleye and yellow perch, Perca flavescens.

SITE LOCATION AND DESCRIPTION

Falcon Creek

Draining an area to the north and west, Falcon Creek represents the major inflow to Falcon Lake (Figure 1). Spawning sites for walleye are lacking in Falcon Lake and its surrounding watershed (Moenig et al. 1978). Enhancement of spawning habitat was thus initiated in order to increase the size of the lake's walleye population, possibly raising low recruitment rates. Earlier investigations suggested maximum fish production had not yet been attained and spawning habitat might be a limiting factor (McGarry 1985).

Three spawning bed rehabilitation sites on this creek, each constructed in 1984 utilizing 76.5 m^3 of 7.5-10.0 cm cobble, were examined. Site #1 is below the culvert crossing on the Beaver Creek Campground Road. Site #2 is again below a culvert crossing on the golf course service road and the third and last site, Site #3 was approximately 50 m downstream of the golf course service road in a shady

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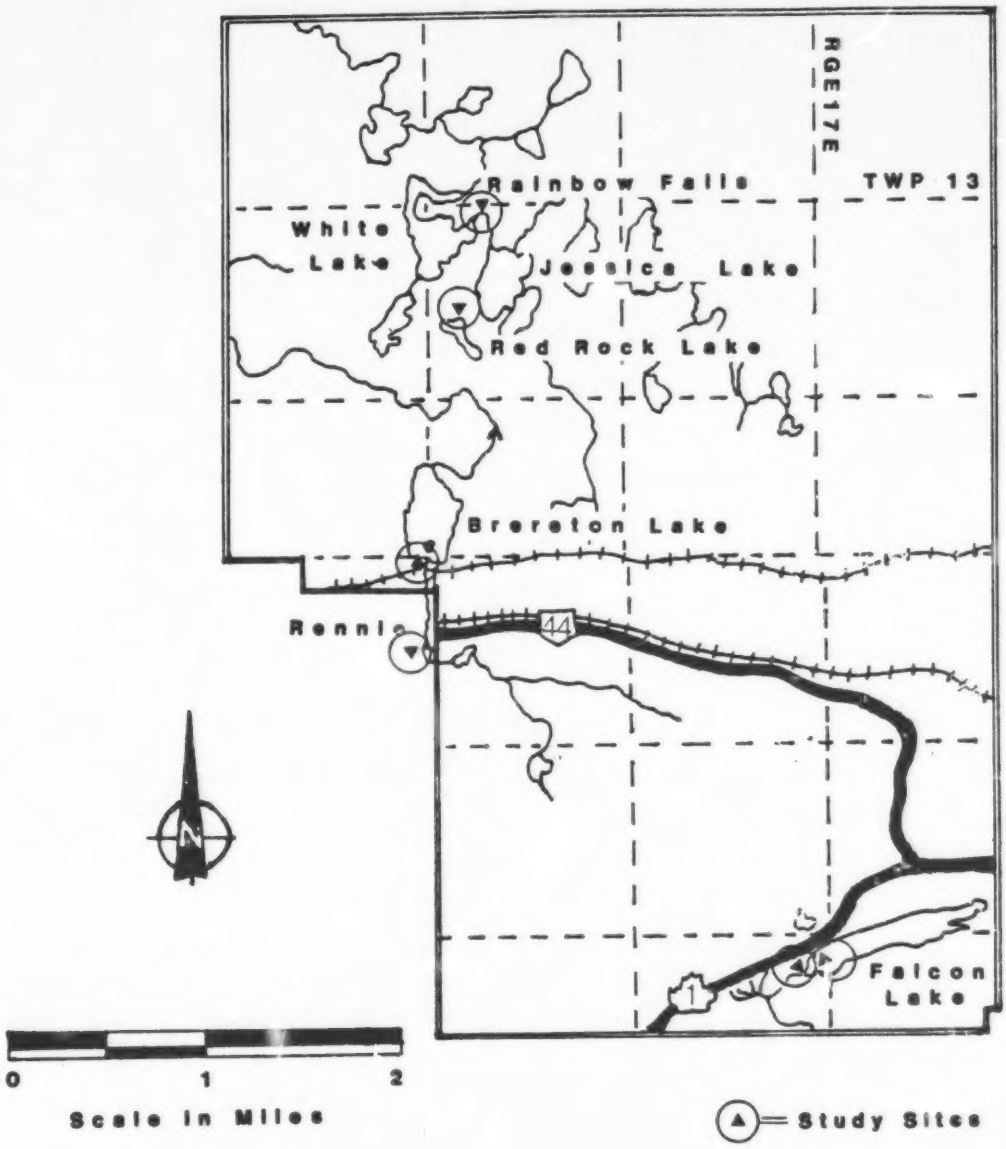


Figure 1. Whiteshell Provincial Park map showing location of habitat enhancement study sites.

riffle section (Figure 2).

Hamilton's Creek

Hamilton's Creek is approximately 3 Km long and flows from Edgar Lake into Falcon Lake on the north shore near Faloma Beach (Figure 1). Its banks, composed of sandy clay, are slightly undercut, and stream cover is provided by shrubs and the surrounding forest.

One spawning bed site was selected on Hamilton's Creek where 76.5 m^3 of 7.5-10.0 cm cobble was placed in 1984. The enhancement site is located in a riffle area 10.0 m below the Trans Canada Pipeline (Figure 3).

Rainbow Falls

A third location determined for spawning bed enhancement was Rainbow Falls which is accessible off Provincial Road #307. The Whiteshell River enters White Lake at Rainbow Falls. The falls are an obstruction to upstream migration except at very high flows, hence this was the area chosen for enhancement and the creation of gravel and cobble spawning beds (Figure 4).

Substrate improvement consisted of 76.5 m^3 of cobble laid in March of 1985. The area below the falls is a known walleye spawning area and its hydraulics and substrate parameters were considered excellent for spawning walleye (McGarry 1985).

Rennie River

Rennie River provides the only stream spawning habitat for walleye in Brereton Lake (Figure 5). Two enhanced spawning sites, each utilizing 76.5 m^3 of cobble, were studied. Site #1 is approximately 20 m downstream of the Ducks Umlimited water control structure at Alf Hole Goose Sanctuary (Figure 6) and Site #2 is

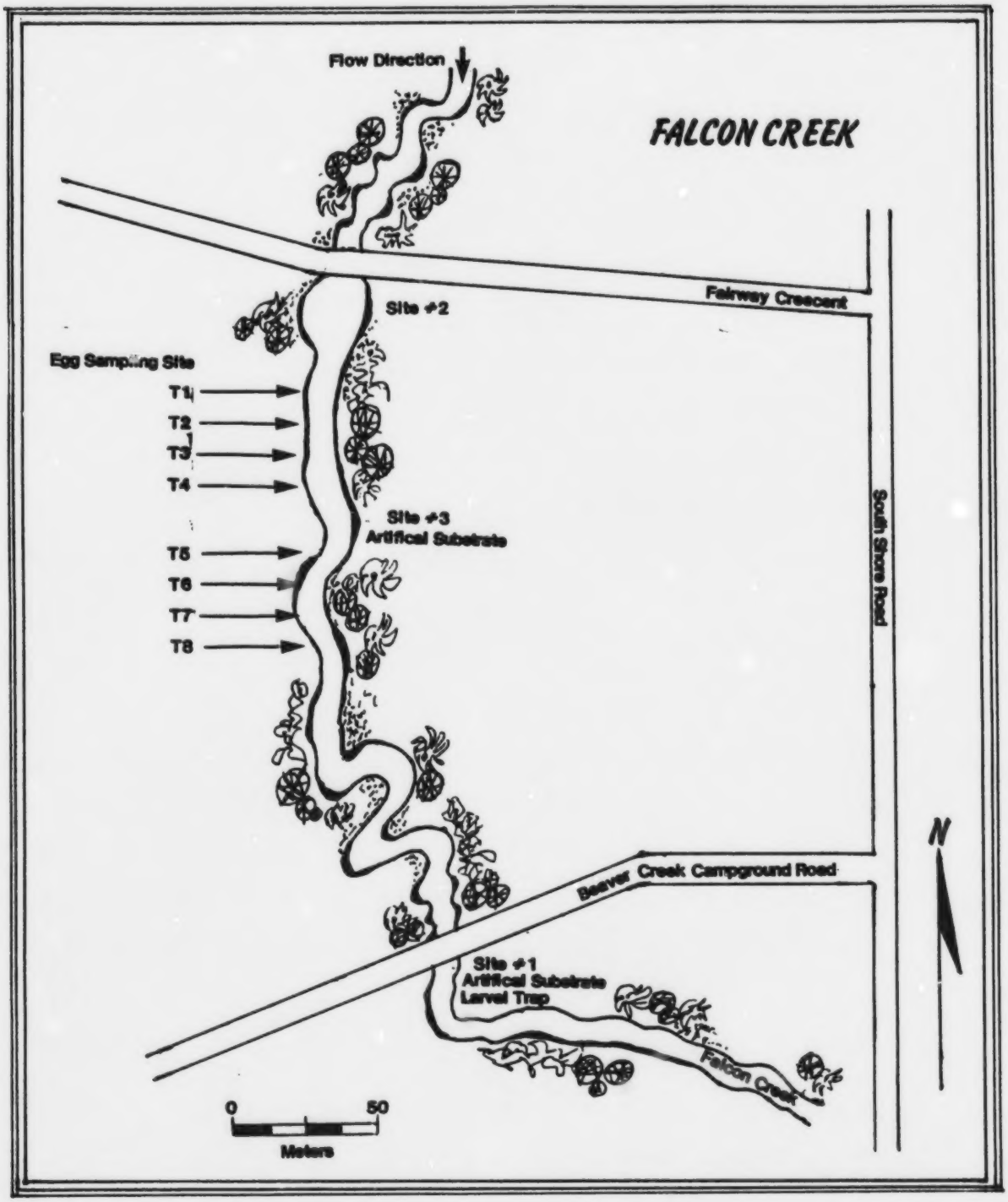


Figure 2: Falcon Creek location map illustrating enhancement site, riffle section and transect locations for egg sampling.

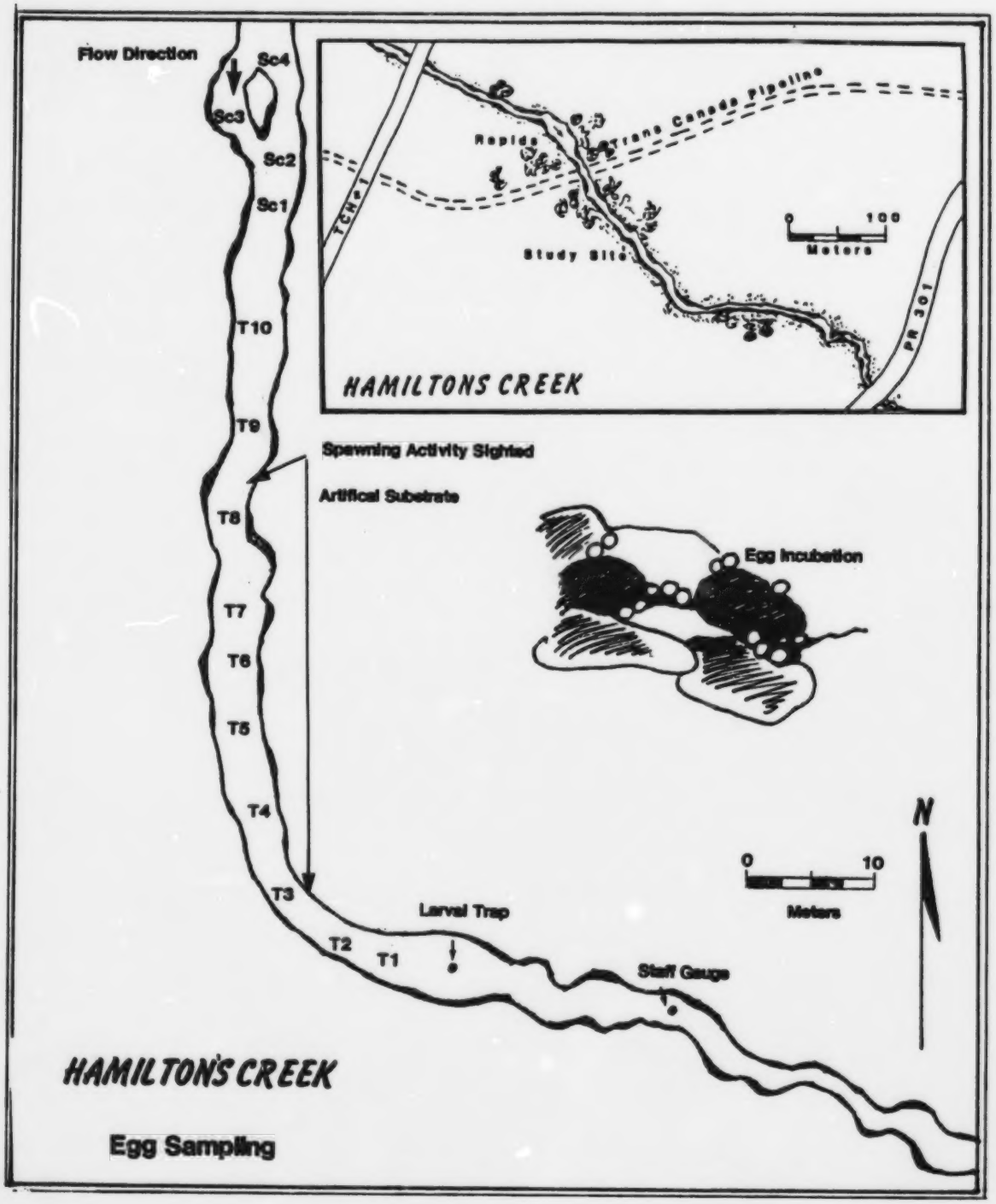


Figure 3: Hamilton's Creek location map illustrating study and enhancement site, egg transect (T) and spot check (Sc) locations, and sites of observed spawning activity.

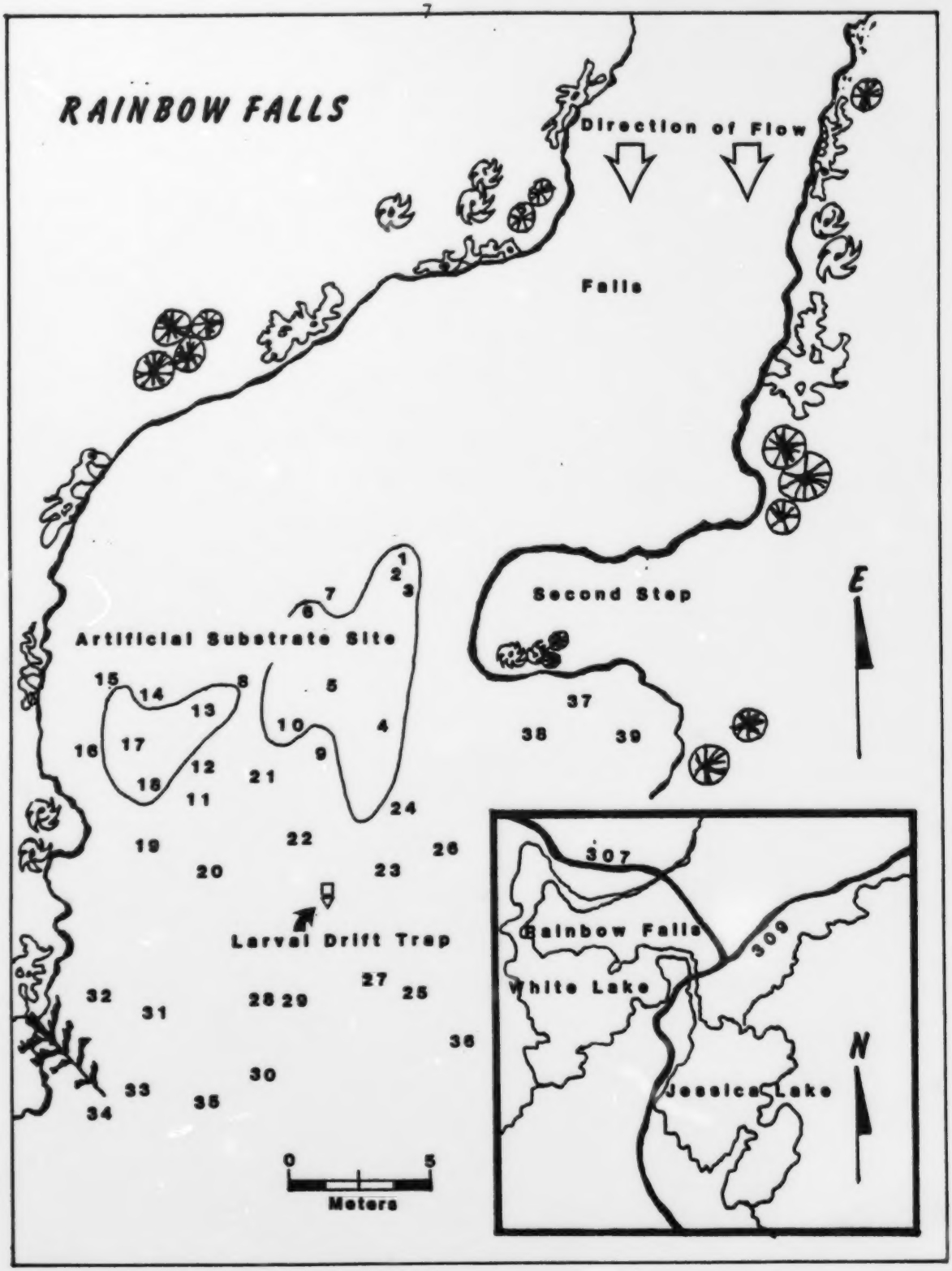


Figure 4 Location and enhancement site map for Rainbow Falls showing habitat enhancement area, larval drift trap and egg sampling sites.

RENNIE RIVER SITES

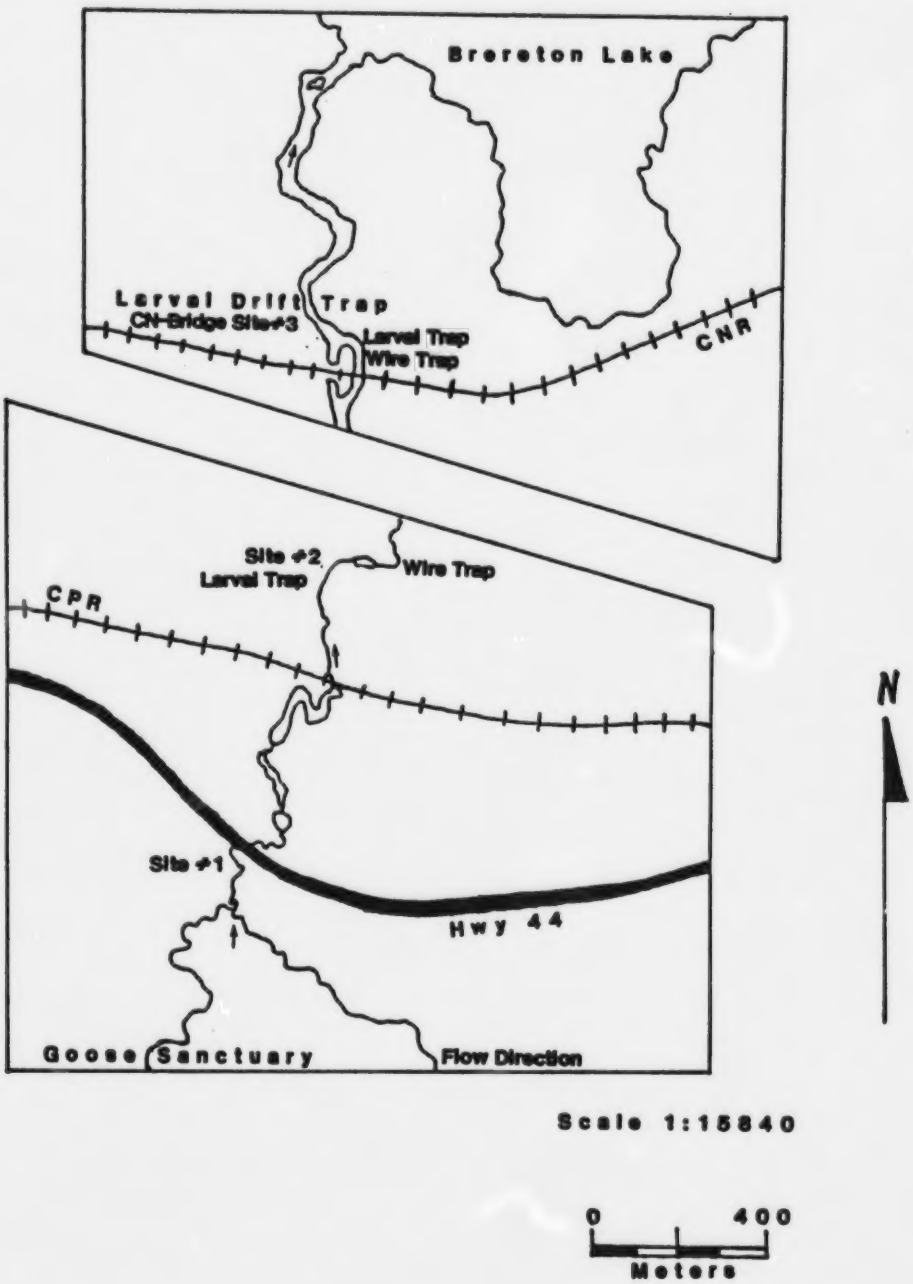
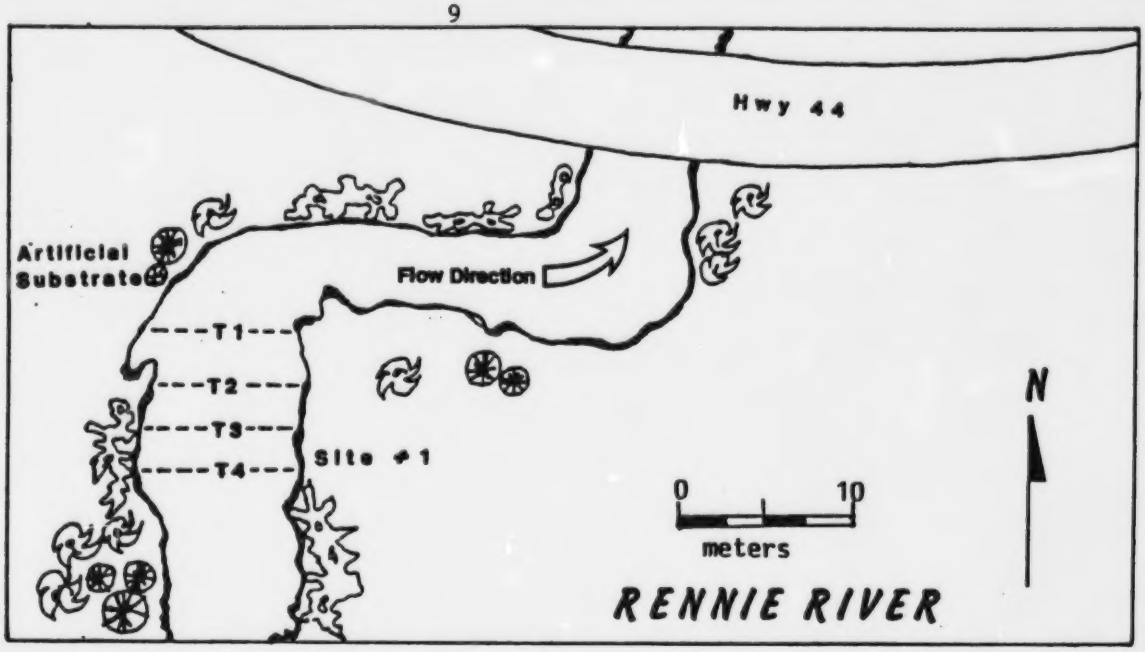


Figure 5. Rennie River location map showing enhancement sites, larval drift station and small wire trap placement.



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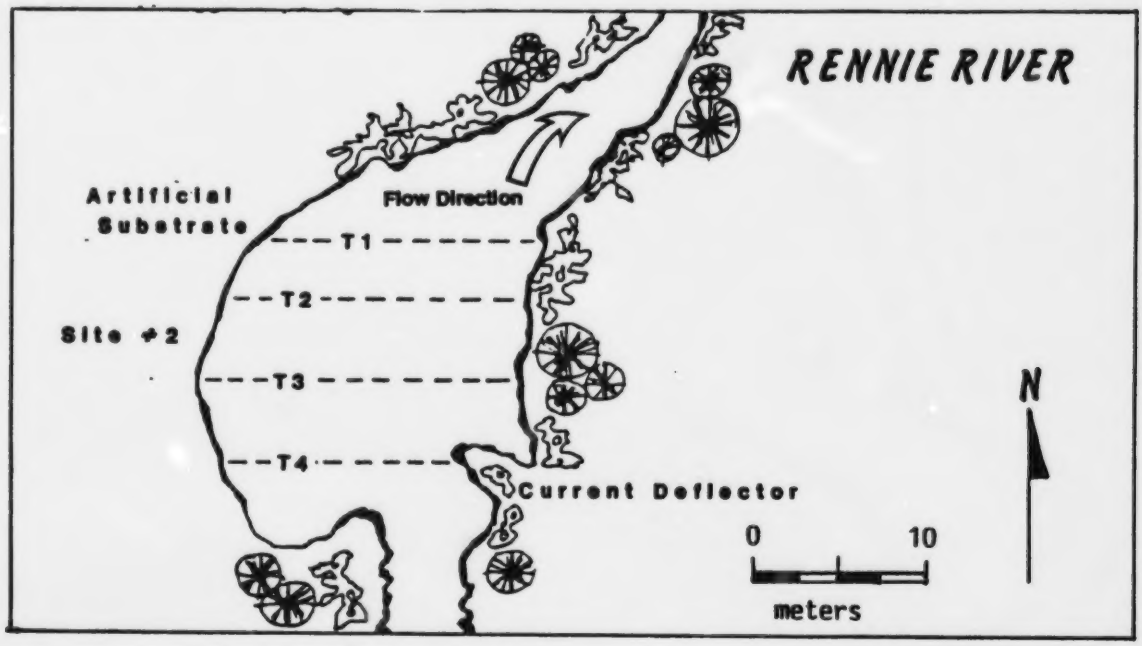


Figure 6. Rennie River - Site #1 station map showing locations of egg sampling transects.

Figure 7. Rennie River - Site #2 station map showing locations of egg sampling transects.

approximately 300 m downstream of the Canadian Pacific Railway Line (Figure 7).

Red Rock Lake

In 1984, artificial spawning beds were created on Red Rock Lake, situated 14.5 Km north of Rennie on the west side of Provincial Road #307 (Figure 8). The lake has an area of approximately 130 ha (325 Ac) and a maximum depth of 4.88 m (16 ft). Several beds of gravel and cobble were laid down within a meter of the shoreline with water depth over the beds ranging from approximately 0.3 to 0.9 m.

The only inflow is runoff from the surrounding area. There is one outflow on the north-east shore near the enhanced spawning beds. Discharges to Jessica Lake and water elevation on Red Rock Lake are controlled by a low head fixed-crest concrete weir (Figure 8). Discharges out of Red Rock Lake cease soon after spring runoff.

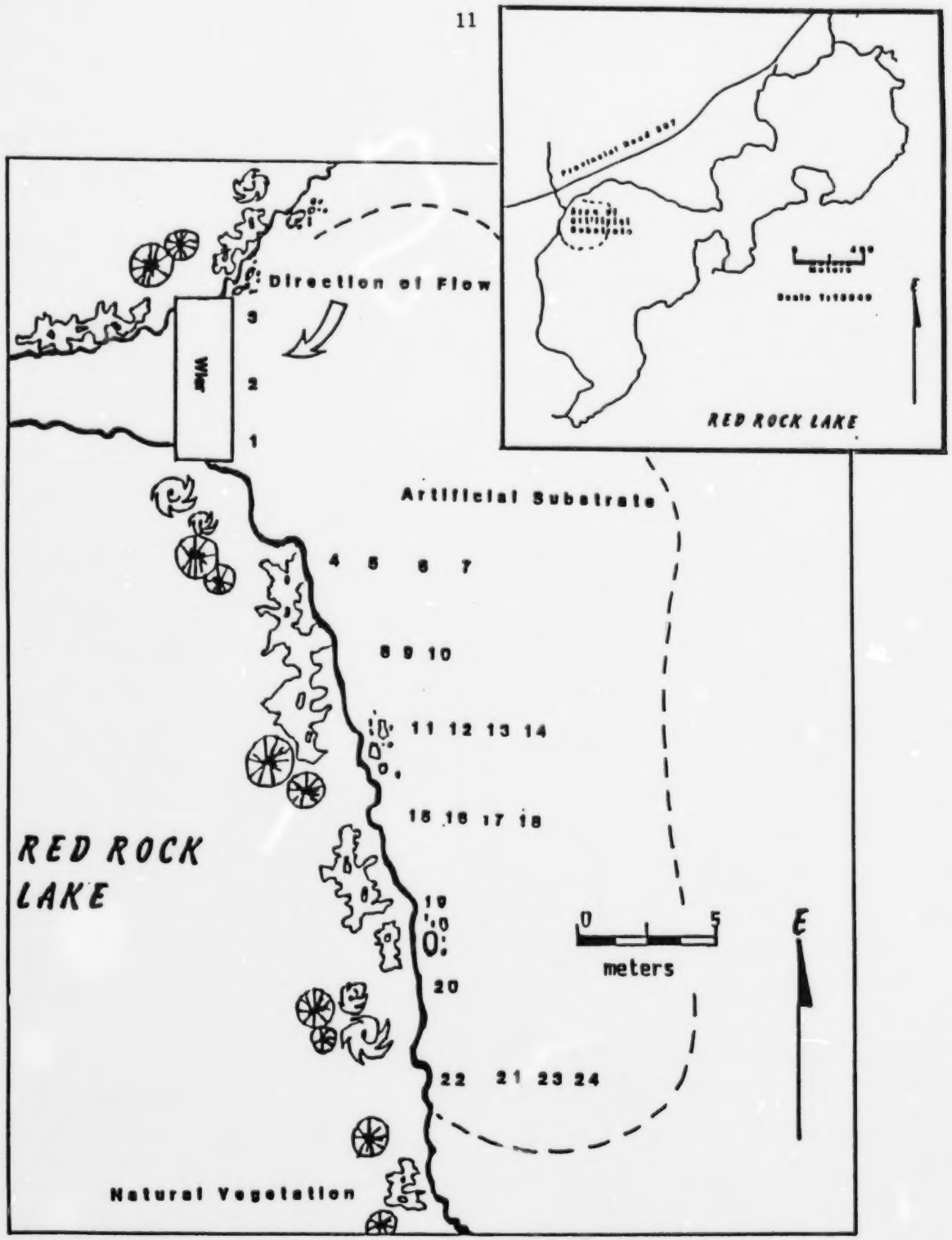


Figure 8. Red Rock Lake location map showing extent of artificial substrate and site specific locations for egg sampling.

MATERIALS AND METHODS

Spawning Observations

Several different methods were employed during this project because of the many different stages in the walleye reproductive cycle. Shortly after spring break-up, when water temperatures begin to rise, walleye move into the streams to spawn. Observations at the spawning sites were therefore required at this time. Evening observations of spawning walleye included night lighting with a 300,000 candle-power spotlight at each of the spawning sites in and around the artificial substrate beds at all enhancement locations within the Park.

Where this was not possible, because of adverse water depths and/or turbidity, small wire fish traps were used to monitor migration to the spawning sites. It was not possible to cover all the sites around the Park every night, but the circuit was completed over a period of several late afternoons and evenings, between April 23 and April 30.

Egg Sampling

After the spawning period, egg samples were obtained from the enhanced spawning sites in order to estimate use by walleye. Intensive egg sampling occurred between April 28 and May 5. Transects were spaced 10.0 m apart at each of the required sites. Three egg sample sites were taken across each transect representing the different habitat areas on the cross sections (Figure 9). All sampling proceeded in an upstream manner so as not to disturb future sample sites. Where transects were not appropriate, samples were taken randomly over the spawning area. Egg samples were taken with a Guzzler-Model 600 suction pump apparatus.

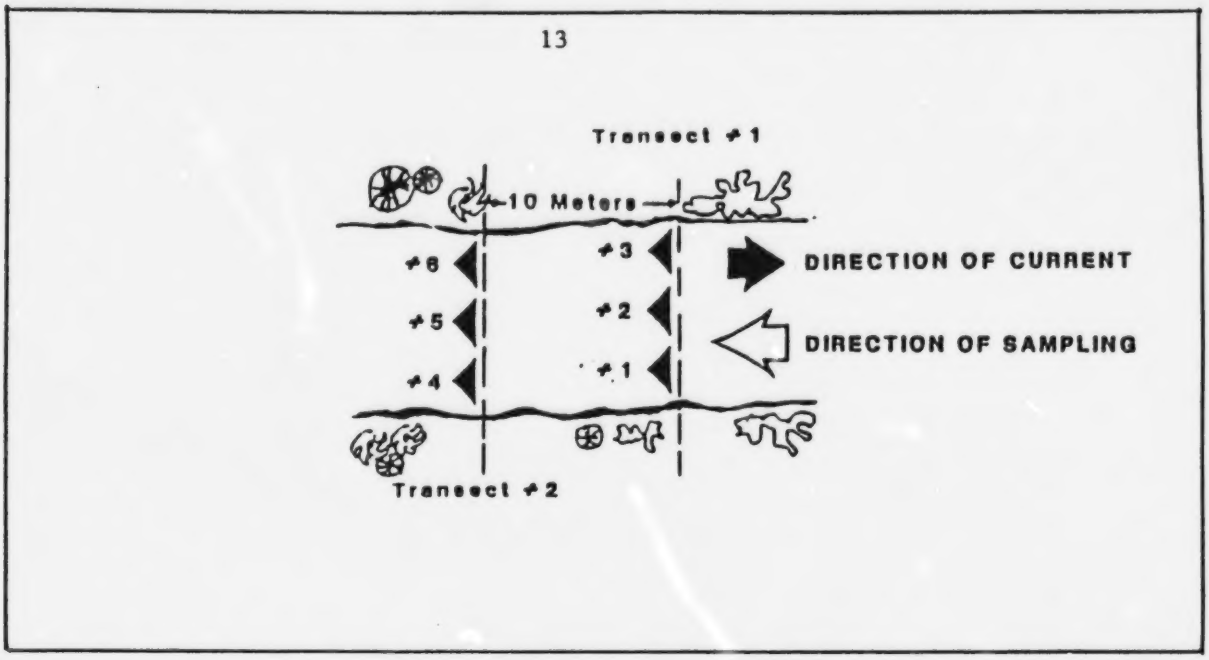


Figure 9. Diagramatic representation of egg sampling methodology.

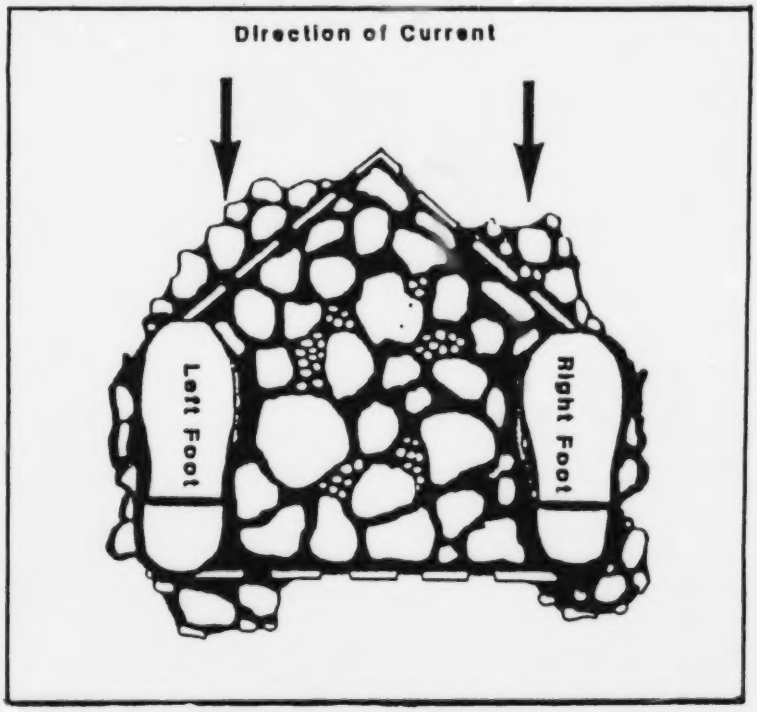


Figure 10. Diagramatic representation of area (approximately half a square meter) sampled for eggs.

The sample area was approximately 0.5 m^2 for each of the three sites along the transect (Figure 10). Walleye eggs were identified and counted at the time of sampling only when sample numbers and debris accumulation permitted. To facilitate walleye egg identification and counting in the field, the eggs were floated in a saturated sugar solution. Samples with large numbers of eggs or excessive debris were immediately packaged and preserved in 10% formalin. These samples were later sorted in the laboratory. For each sample, walleye eggs were separated and counted as either viable (live) or non-viable (dead/unfertilized) by observing them under a binocular microscope. An egg was considered to be dead if it was milky white, black, or yellowish and completely opaque. Clear eggs with a developing blastodisc or embryo present were considered to be live.

In order to assess the best suitable habitat for egg deposition, incubation, and survival, additional habitat measurements (depth, velocity, and substrate) were recorded on the transects where eggs were sampled. Habitat measurements were restricted to Hamilton's Creek and Rennie River - Site #1.

Larval Drift Sampling

Larval drift traps, based on the original design by Burton and Flannagan (1976), were used to capture walleye fry (Figure 11). The larval drift trap consisted of a 15 x 15 cm aluminum hood with a nitex (750 µm) mesh conical net. At the downstream end of the trap there was a removable 1.0 l nalgene container which filtered the flow and captured larval fish. Once site specific locations were determined, the larval drift traps were placed in areas of strong current approximately 20 to

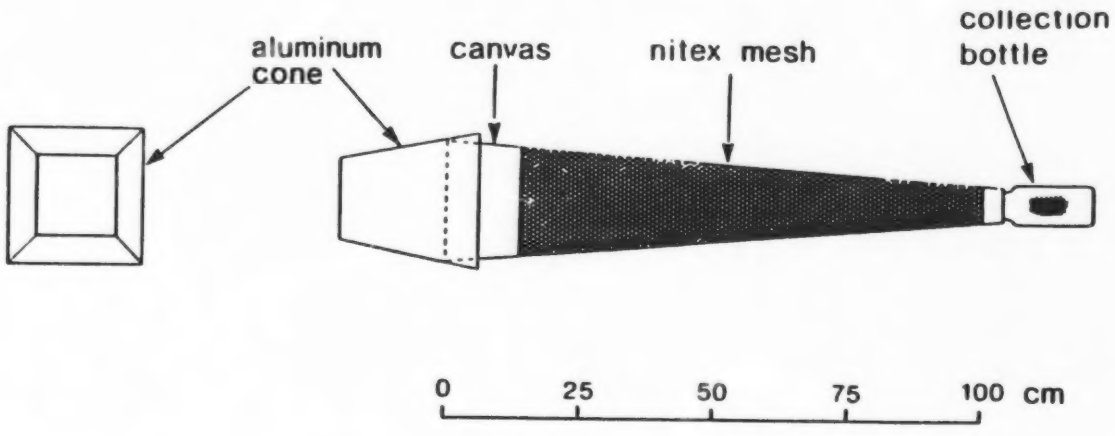


Figure 11. Specifications of larval drift trap with conical net and aluminum hood used to capture fishes.

25 cm below the surface and as far as possible downstream insuring that all the spawning grounds were included.

Drift nets were attached between two 2 m long T-posts driven into the streambed. At the Rennie River - CN bridge (Site #3) an alternate type of net set was required because water depth did not allow the T-bar set. The drift net at Site #3 was therefore suspended from two 1/2" threaded rods approximately 20 cm underneath a 1.0 m square raft and attached by a bridle to a pulley system allowing sufficient excess line for retrieving the net (Figure 12).

Larval drift samples were collected daily from May 5 through to and including May 22. All samples were preserved in 10% formalin for future species identification and counting.

Habitat Measurements

The information obtained includes stream descriptions and hydrological measurements. Not all measurements were done in every location due to adverse stream conditions and/or difficult access. Water depths, velocities, substrate type, and temperature were measured at all locations except Red Rock Lake. Temperatures were carried out in conjunction with spawning observations and egg sampling.

Discharges had to be determined for Hamilton's Creek because it was an ungauged stream. It was therefore necessary to establish a staff gauge at the creek for daily water readings during the spawning/incubation and larval drift periods. A stage - discharge curve was computed for the gauge.

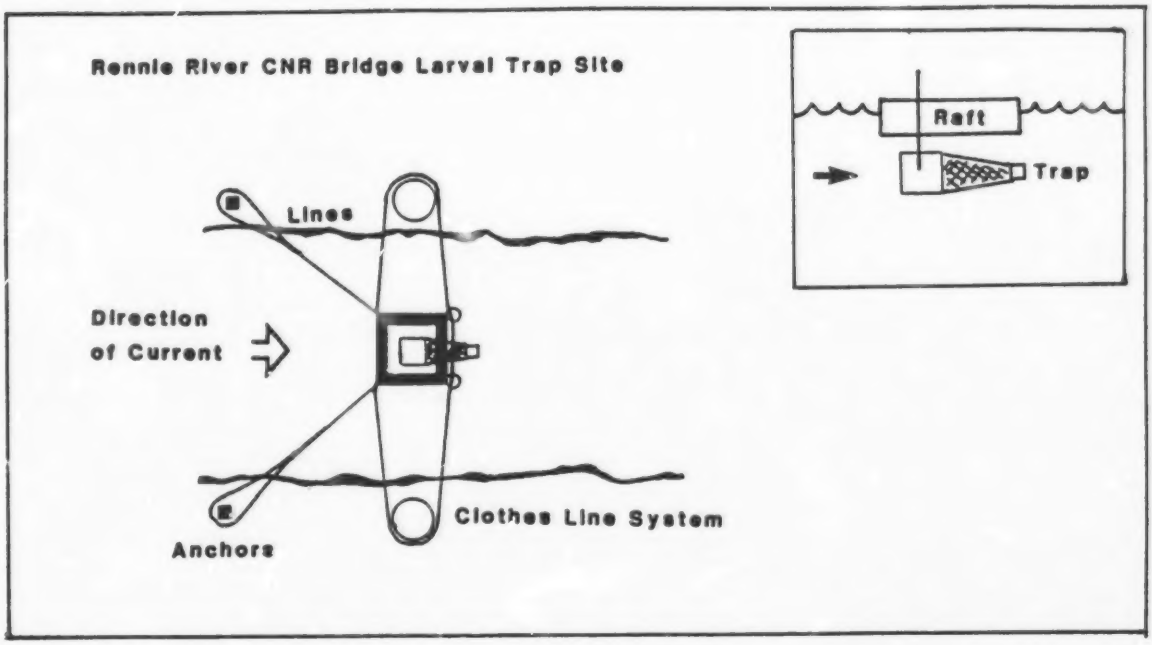


Figure 12. Larval drift trap design and set up for the Rennie River - C.N. Bridge site.

Larval Morphology

Larval samples were identified using several different taxonomic keys and journal articles (Auer 1982, Li and Mathias 1983, Nelson 1968). The main characteristics of larvae determination used were: total length, yolk-sac type, ratio of pre-anal to post-anal lengths, post-anal myomere counts and chromatophore patterns. Other morphological characteristics were noted through microscopic observations but may only be applicable to local examples. Samples were identified using a binocular dissecting microscope with measuring capability. Other representative larvae were examined and photographed using a Leitz Wetzlar Orthomate - W fully automatic microscope camera for 35 mm slide format. Film type used was Ektachrome, ASA 100.

Calculations

It was necessary to make inferences on the proportion of viable walleye eggs on different substrate types. Thus, a small-sample statistical test and estimation procedure for testing hypotheses concerning population variances was attempted for the data on Hamilton's Creek. However, for this type of data, where on theoretical grounds the population sampled was not normal, corrections were made possible by transforming the data. It is known from statistical theory that percentages form a binomial, rather than a normal distribution, the deviation form normality being great for small or large percentages (0 to 30% and 70 to 100%).

If, rather than simply having percentages of one's data one knows the actual proportions x/n, in a binomial distribution the square root of each proportion can be transformed to its arcsine (i.e. the

angle whose sine is $\sqrt{p}$). The result is that the data will have an underlying distribution that is nearly normal. This arcsine transformation can be further improved by replacing 0/n with 1/4 n and n/n with 1-1/4 n. Below is the resultant formula utilized, the Freeman and Tukey (1950) (see Zar 1984) arcsine transformation:-,

$$p = 1/2 \left[\text{arcsine} \sqrt{\frac{x}{n+1}} + \text{arcsine} \sqrt{\frac{x+1}{n+1}} \right]$$

RESULTS

Spawning Observations - Falcon Creek

Spawning observations, initially lower in priority relative to other methods employed in this project, proved to be most beneficial. Evening observations on April 23 and 24 at the Beaver Creek Road culvert, Fairway Crescent culvert, and the artificial riffles in the habitat enhancement zone showed only the presence of white suckers, Catostomus commersoni (Figure 2). No northern pike, Esox lucius, or walleye were observed. From local reports, white sucker were seen as far upstream as the riding stables on Falcon Creek. Northern pike were said to have been observed upstream of the culvert on the service road. There were no reported sightings of walleye at any of these locations.

Upstream migration in Falcon Creek was monitored by Fish Culture Staff from the Whiteshell Hatchery. The upstream migration peaks of walleye were confined to April 19, 20 and 21 with catches of; 29 females - 43 males, 50 females - 50 males and 29 females - 34 males, respectively. The number caught diminished on April 22 with a total catch of only eight females and continued to decline until April 27, the end of the walleye run. Only 25 of the 116 females were stripped of their eggs, and 43 were released unstripped upstream of the pound net.

Spawning Observations - Hamilton's Creek

Nightlighting on April 23 revealed that walleye migrate upstream to within 40 m downstream of Hwy. #1. The highest density of walleye was observed at the pipeline crossing (Figure 3). Walleye were frequently observed near and on the spawning substrate that was

placed in 1984. White suckers were also abundant. Observations made during daylight hours indicated that walleye were relatively inactive, seeking cover in deeper pools, debris jams and undercuts in the creek's bank. An important selective factor for walleye in holding positions was areas of reduced water velocities in the proximity of the spawning beds. One sighting actually made during daylight hours illustrated that eggs were broadcasted in relatively shallow waters, approximately 0.4 - 0.5 m deep. The female was observed holding on an approximate 40° angle off the horizontal, head lowered, and tail elevated above the water surface. While releasing milt, the male remained horizontally suspended just above head level of the broadcasting female, approximately half a meter upstream (Figure 13).

Spawning Observations - Rainbow Falls

Whiteshell River night observations on April 23 indicated that the upper extent of walleye spawning movement from White Lake was to Rainbow Falls. Besides hundreds of white suckers, walleye were observed in back eddies immediately below the falls on the artificial substrate, and below the second step of the falls (Figure 4).

Spawning Observations - Rennie River

Nightlighting at Rennie River on April 23 proved to be ineffective. Water depths did not provide adequate light penetration making observations of spring migration impossible. To help compensate for poor nightlighting conditions, wire mesh traps were placed in Rennie River at three locations; Site #3 (CN bridge), Site #2 and at location approximately 500 m downstream on Site #2. Catches of white suckers

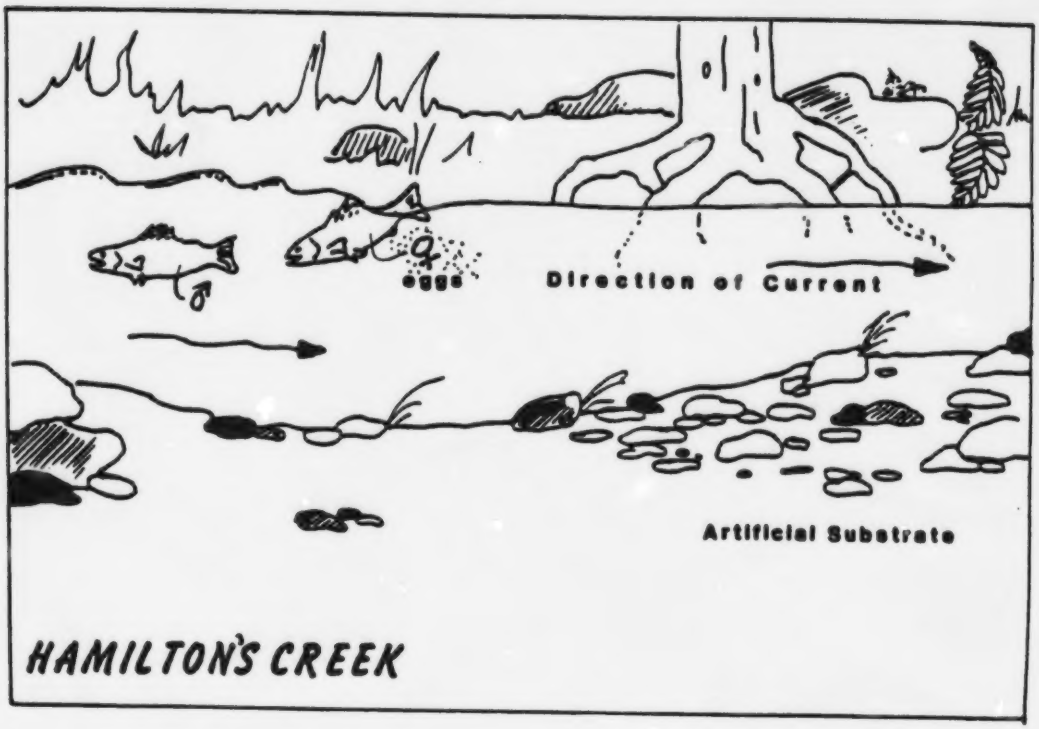


Figure 13. Diagramatic representation of walleye positioning and broadcasting eggs at Hamilton's Creek.

were 1, 37 and 5, respectively, at the three locations. Unfortunately, walleye tended to evade the traps.

Spawning Observations - Red Rock Lake

Conditions for visual observation proved to be inimical at the Red Rock lake spawning bed location, so nightlighting was not attempted.

Egg Sampling - Falcon Creek

Only white sucker eggs were identified at Sites #1 and #2. Examination of Site #3, on May 5 provided a single viable walleye egg (Figure 2). The egg's location was the first riffle downstream of the culvert on the artificial substrate at transect #4. Water depth and substrate type at this location were 24 cm and cobble-rock, respectively.

Egg Sampling - Hamilton's Creek

From April 28 to May 1, a total of 10 transects and nine spot checks on Hamilton's Creek were sampled for walleye eggs. The sampled area covered a 130 m section of the stream on substrate types varying from fine silt with submergent vegetation to large rocks in water depths ranging from 5 to 52 cm. The total number of eggs collected per site ranged from zero to 651 (Table 1).

A small sample statistical test and estimation procedure was performed on this data. The Freeman and Tukey (1950) (see Zar 1984) arcsine transformation was used on the acutual proportions of viable versus non-viable walleye eggs for both silt/soil and sand/cobble

Table 1. Viable walleye egg numbers and related habitat parameters for Hamilton's Creek.

Date	Distance from staff gauge (m)	Site number	Total Depth (cm)	Velocity (m/sec)	No viable eggs/ total No. eggs	Substrate type
April 28	0.0	1	52.0	0.126	12/17	sand-cobble
April 28	0.0	2	26.0	0.070	13/18	sand-cobble
April 28	0.0	3	44.0	0.032	1/4	silt-soil
April 28	10.0	1	44.0	0.030	31/33	sand-cobble
April 28	10.0	2	48.0	0.191	32/37	sand-cobble
April 28	10.0	3	30.0	0.135	61/90	cobble
April 29	20.0	1	16.0	0.158	119/127	sand-cobble
April 29	20.0	2	5.0	-	223/241	sand-cobble
April 29	20.0	3	42.0	0.253	67/67	sand-cobble
April 29	30.0	1	14.0	-	90/137	silt-soil
April 29	30.0	2	20.0	0.469	15/26	cobble
April 29	30.0	3	14.0	0.885	35/35	cobble
April 29	40.0	1	12.0	-	159/336	silt-soil
April 29	40.0	2	20.0	0.184	37/37	cobble
April 29	40.0	3	42.0	0.079	18/33	sand-cobble
April 29	50.0	1	28.0	0.076	294/476	sand-cobble
April 29	50.0	2	28.0	0.087	33/37	cobble
April 29	50.0	3	20.0	0.067	386/651	silt-soil
May 1	54.0	1	30.0	0.453	14/15	sand-cobble
May 1	56.0	1	18.0	0.341	0	sand-cobble
May 1	60.0	1	16.0	0.141	5/9	sand-cobble
May 1	70.0	1	30.0	0.033	72/312	silt-soil
May 1	70.0	2	42.0	0.073	48/64	silt-soil
May 1	70.0	3	29.0	0.110	67/195	silt-soil
May 1	80.0	1	22.0	0.160	290/375	sand-cobble
May 1	80.0	2	13.0	0.078	252/315	sand-cobble
May 1	80.0	3	18.0	0.117	78/100	sand-cobble
May 1	90.0	1	14.0	0.061	5/6	sand-cobble
May 1	90.0	2	25.0	0.112	10/11	sand-cobble
May 1	90.0	3	24.0	0.085	21/21	sand-cobble
May 1	110.0	1	-	-	0	-
May 1	120.0	1	-	-	0	-
May 1	130.0	1	-	-	0	-

substrates. Results illustrated that egg survival was significantly higher on sand/cobble substrates than on silt/soil ($t = 4.42$, 27 df, $p<0.005$).

Keeping flow relatively constant resulted in daily battles with beaver upstream of the artificial spawning beds. To maintain sufficient flow, small portions of the upstream beaver dams were opened so as not to release large quantities of silt to the downstream spawning site. Frequent inspection of the upstream reaches and water depth at the spawning beds was therefore a necessity.

Under conditions of low discharge, large numbers of eggs were drying out in side pools isolated from the main stream flow. Conditions such as these destroy the impermeability of the membrane, water enters, and salts are lost from the yolk. This loss of salts causes globulins to be precipitated and the entire egg ends up turning white.

Egg Sampling - Rainbow Falls

Stream transects were not attempted at this location because of high flow conditions and water depths creating difficult access. A total of 39 egg sampling sites were therefore chosen at random on and downstream of the artificial substrate (Figure 4). A total of 16 walleye eggs and literally thousands of white sucker eggs were collected (Table 2).

Egg Sampling - Rennie River

Egg sampling in Rennie River commenced on April 30. Four cross sections, each with three sites were established and sampled at both Sites #1 and #2 (Figures 6 and 7). Velocity and depth measurement

Table 2. Walleye egg numbers and locations on experimental gravel beds at Rainbow Falls, May 5, 1987.

Site number(s)	Walleye eggs
1 - 5	-
6	2
7 - 13	-
14	1
15 - 18	-
19	2
21 - 27	-
28	3
29	1
30 - 31	-
32	1
33 - 34	-
35	2
36	3
37	1
38 - 39	-

Note: White sucker (*Catostomus commersoni*) eggs were abundant at every site location.

however, were only recorded at Site #1 (Figure 6) where a total of 25 (7 viable) walleye eggs were found (Table 3). On-site egg identification at Site #2 yielded no walleye eggs and so habitat measurements on transect sites were omitted. White sucker eggs were abundant at both locations on every site.

Egg Sampling - Red Rock Lake

The artificial spawning bed substrate at Red Rock Lake was sampled on May 5. A total of 24 sites were sampled on the artificial spawning substrate (Figure 8). No walleye eggs were collected but white sucker eggs were abundant (not counted).

In a location adjacent to the artificial spawning substrate, approximately 0.2 m from shore, 38 walleye eggs (non-viable) were collected from Site #22 (Figure 8).

Larval Drift - Falcon Creek

Larval drift sampling on Falcon Creek commenced on May 6, and continued through to and including May 21. The main finding of the larval drift catch data was the absence of walleye.

Larval Drift - Hamilton's Creek

Larval walleye drift from Hamilton's Creek began on May 7, and continued until May 15 with peaks on May 8 and 9 (Tables 4 and 5). The drift sampling period continued until May 21. Only two species of larval fish were caught and identified, walleye and white sucker. The total larval walleye drift number for the period between May 7 and

Table 3. Viable walleye egg numbers and related habitat parameters for Rennie River - Site #1, April 30, 1987.

Distance from staff gauge (m)	Site number	Total depth (cm)	Velocity (m/sec)	No.# viable eggs/ total No.# eggs	Substrate type
0.0	1	52.0	0.130	1/6	sand-cobble
0.0	2	44.0	0.184	2/6	silt-soil
0.0	3	64.0	0.273	2/2	cobble
5.0	1	40.0	0.341	1/1	cobble
5.0	2	36.0	0.273	0/1	cobble
5.0	3	52.0	0.253	0	cobble
10.0	1	58.0	0.153	0/1	sand-cobble
10.0	2	50.0	0.156	0	silt-soil
10.0	3	34.0	0.253	0	silt-soil
15.0	1	64.0	0.307	1/7	sand-cobble
15.0	2	52.0	0.307	0	sand-cobble
15.0	3	30.0	0.250	0	sand-cobble

Table 4. Larval walleye catches at habitat enhancement sites throughout the Whiteshell Provincial Park, May, 1987.

Date	Hamilton's Creek	Falcon Creek	Rennie River Site #2	Rennie River Site #3	Rainbow Falls
May 6	–	–	–	5	–
May 7	12	–	–	–	11
May 8	123	–	–	3	7
May 9	100	–	–	3	4
May 10	10	–	–	1	–
May 11	2	–	–	–	–
May 12	–	–	–	–	–
May 13	1	–	–	–	–
May 14	2	–	–	–	–
May 15	1	–	–	–	–

Table 5. Larval walleye caught at Hamilton's Creek and their estimated daily total numbers, May, 1987.

Date	Trap velocity (m/sec)	Total discharge (Q) (m^3/sec)	Percentage of flow sampled	Number caught	Estimated total number
May 7	*0.260	0.0475	12.42	12	97
May 8	0.130	0.035	8.29	123	1484
May 9	*0.0605	0.0225	6.23	100	1605
May 10	0.009	0.01	2.00	10	500
May 11	*0.018	0.015	2.67	2	75
May 12	0.029	0.02	3.25	0	0
May 13	*0.048	0.0195	5.64	1	18
May 14	0.082	0.019	9.74	2	20
May 15	0.081	0.018	10.00	1	10
				Total 251	3809

* Velocity readings taken at drift trap mouth (area = 0.0225 m^2)

May 15 was 251, with a peak of 123 on May 8 (Figure 14). The estimated total number of walleye fry for this period was 3809.

Larval Drift - Rainbow Falls

The larval drift station on the Whiteshell River was located approximately 10-15 m downstream of the artificial substrate spawning grounds at Rainbow Falls (Figure 4). Larval drift sampling began on May 6 and continued through to and including May 21. Initially three larval drift traps were set at this station until trap velocities and trap catches determined the best location. Two traps set in slower moving water were removed. Total catch of walleye fry in the single trap was 22, with catch results bracketed between May 7 and 9 (Figure 14). The greatest number of walleye fry caught for a 24 hr period was 11 on May 7 (Table 4). The estimated daily totals for May 7, 8 and 9 were 4528, 2123 and 975 respectively, with an overall estimated total for this period of 7626 (Table 6).

Other larval species captured were white sucker, yellow perch, unidentified minnows and burbot (Lota lota). Drift catches also produced large quantities of cladocerans and chaoborus larvae, both of which are excellent forage for post-larval walleye.

Larval Drift - Rennie River

The Rennie River stations, Site #2 just downstream of the current deflector and Site #3 at the C.N.R. bridge, were also monitored from May 6 to 21 (Figure 5). Three species of larval fry were caught and identified from this river - walleye, yellow perch and white sucker. Drift catches at Site #2 recorded yellow perch and white sucker

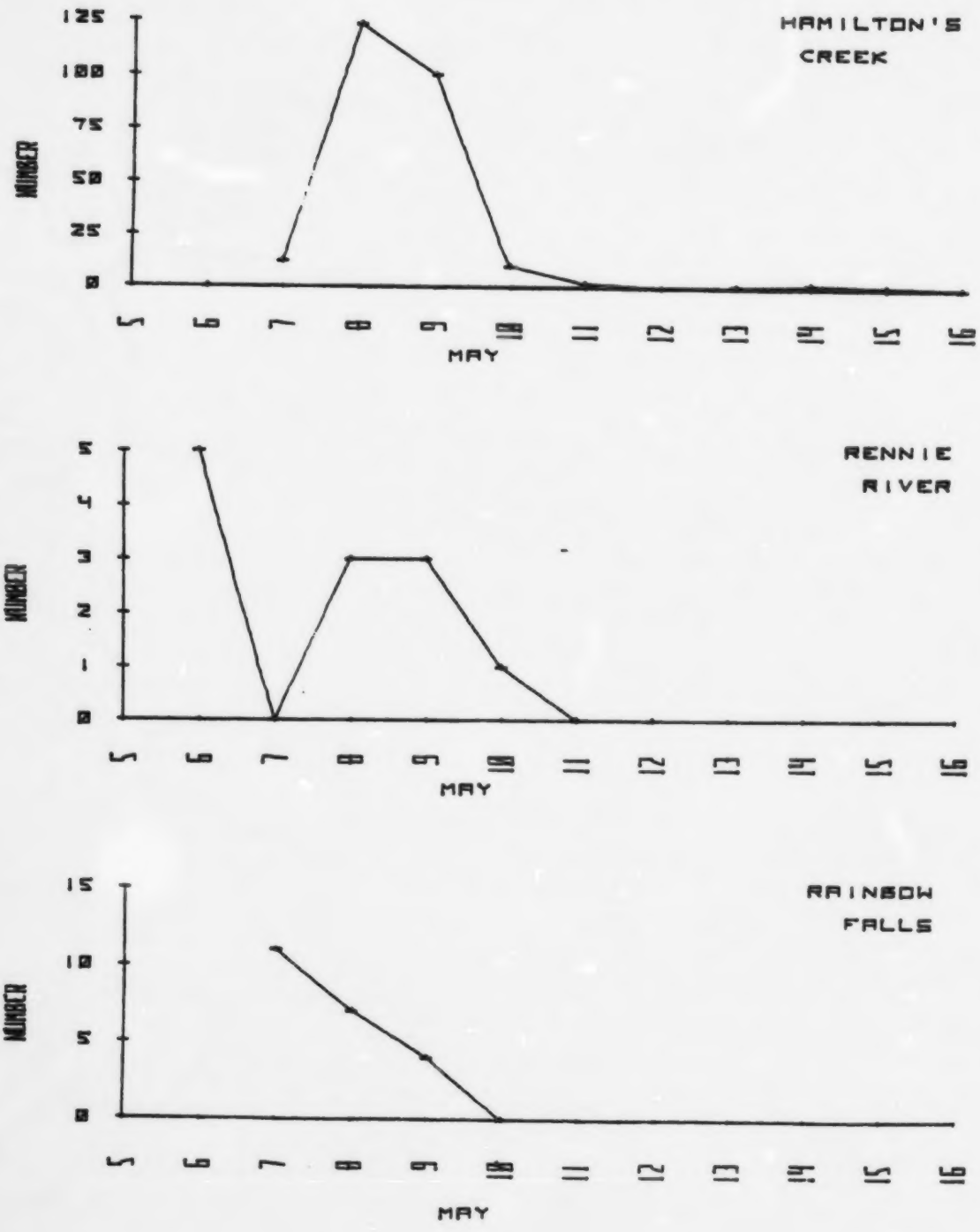


Fig. 14. Larval drift net sample results of walleye (Stizostedion vitreum) for the spring of 1987 at study sites in the Whiteshell Provincial Park.

Table 6. Larval walleye caught at Rainbow Falls (Whiteshell River) and their estimated daily total number, May, 1987.

Date	Trap velocity (m/sec)	Total discharge (Q) (m^3/sec)	Percentage of flow sampled	Number caught	Estimated total number
May 7	0.287	2.66	0.2429	11	4528
May 8	0.381	2.60	0.3297	7	2123
May 9	0.474	2.60	0.4104	4	975
				Total 22	7626

exclusively. No walleye fry were captured.

The larval drift station at Site #3, (C.N.R. bridge) recorded a total of 12 walleye fry for the period between May 6 and 10 (Figure 14). Larval yellow perch and white sucker were also captured. The estimated total number of walleye fry for this sampling period was approximately 19,987 (Table 7).

Larval Drift - Red Rock Lake

The artificial spawning site on Red Rock Lake did not provide adequate physical conditions for larval drift sampling. Discharge from the concrete weir at the artificially enhanced spawning site was insufficient to effectively fish a larval drift trap (Figure 8).

Larval Morphology

Criteria for walleye and perch identification and separation were numerous (Table 8). The main characteristics of larval determination were: total length, developmental stage, yolk sac shape, ratio of pre-anal to post-anal lengths, post-anal myomere counts and chromatophore patterns. Microscopic examination showed that larval walleye have a sort of rounded head, a tear-drop shaped yolk sac with an anteriorly placed oil globule completely covered with "evenly" distributed small "thin" stellate chromatophores, and pigment which spreads from the ventral ridge up a short distance (approximately 1/3 the way) along the myomere edges (Figure 15).

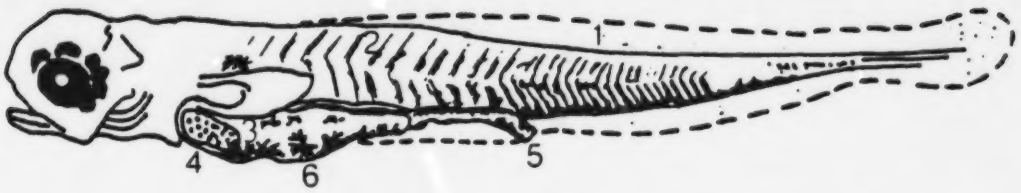
Table 7. Larval walleye caught at Rennie River, Site #3, (C.N.R. bridge) and their estimated daily total numbers, May, 1987.

Date	Trap velocity (m/sec)	Total discharge (Q) (m^3/sec)	Percentage of flow sampled	Number caught	Estimated total number
May 6	0.060	1.84	0.0734	5	6815
May 8	0.027	1.39	0.6438	3	6849
May 9	0.027	1.02	0.0597	3	5022
May 10	0.030	0.88	0.0769	1	1301
				Total 12	19987

Table 8. Morphological characteristics of walleye and yellow perch larvae noted through microscopic examination.

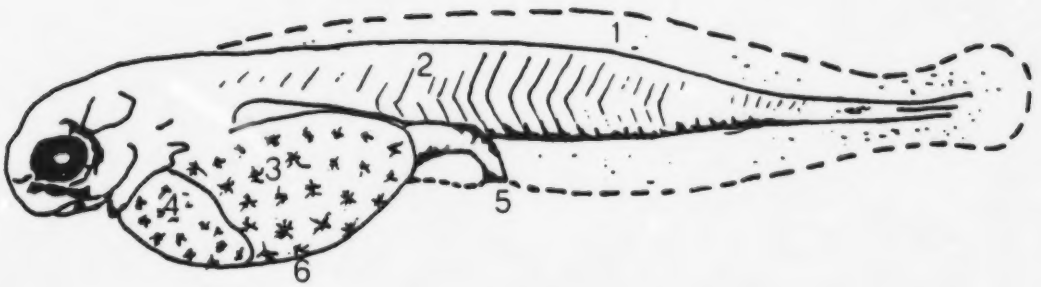
WALLEYE (*Stizostedion vitreum*)	YELLOW PERCH (*Perca flavescens*)
1) total length, 6.0–10.0 mm.	1) total length, 5.0–8.0 mm.
2) greatest body depth, 20% of T.L.	2) greatest body depth 14–16% of T.L.
3) yolk-sac length, 2.13–2.88 mm long.	3) yolk-sac length, 1.1–2.3 mm long.
4) yolk-sac, tear-drop shaped rather than elongated oval shape.	4) yolk-sac, elongated oval shape, more convoluted (wrinkled) appearance.
5) yolk-sac oil globule, anteriorly positioned and occupies 20% of yolk-sac space.	5) yolk-sac oil globule, anteriorly positioned between pectoral fins and occupies 10–12% of yolk-sac space, more rounded shape than walleye yolk-sac oil globule.
6) small thin stellate chromatophores are evenly distributed and cover entire yolk-sac.	6) stellate chromatophores are dark and thick and distribution seems confined to ventral ridge of yolk-sac in chain-like systems.
7) anus length shorter relative to perch and bends abruptly downward.	7) anus length longer relative to walleye and points more in a posterior direction rather than downward.
8) pigmentation between myomeres from ventral ridge to approximately just below lateral line.	8) pigmentation between myomeres much more pronounced and from ventral ridge up to and past lateral line.
9) finfold width relative to body width, greater than that of perch.	9) finfold width relative to body width, thinner than that of walleye.
10) pectoral fin development almost nonexistent.	10) pectoral fin development very pronounced, much larger relative to walleye pectoral fin development.
11) lower jaw does not protrude as far anteriorly as upper jaw.	11) lower jaw protrusion equal with that of upper mandible.
12) >24 post-anal myomeres.	12) 17–20 post-anal myomeres.

* WALLEYE & PERCH FRY OBSERVATIONS FROM SAMPLES TAKEN AT HAMILTON'S CREEK, RENNIE RIVER (CN BRIDGE SITE) AND RAINBOW FALLS (WHITESHELL RIVER).



Perca Flavescens, Yellow Perch
Yolk Sac Larvae 6-8mm

1. Finfold
2. Myomeres
3. Yolk Sac
4. Oil Globule
5. Anus
6. Stellate Chromatophores



Stizostedion Vitreum, Walleye
Yolk Sac Larvae 6-8mm

Fig. 15. Diagramatic representation of yellow perch (Perca flavescens) and (Stizostedion vitreum) larvae.

Yolk sac shape in perch larvae was much more oblong. Also, large dark-colored stellate chromatophores were sparsely distributed and seemed confined to the ventral ridge area. An uneven series of small unequally sized chromatophores were evident in many specimens between the divisions of the myomeres, with the black pigment lines running from the ventral edge to and past the lateral line.

Canine tooth and commencement of the lower jaw articulation were difficult to observe. Pectoral development was also much more advanced in perch larvae in comparison to walleye of the same size.

DISCUSSION

The state of a population of fishes depends upon a complicated system of both environmental and biological factors which affect the reproductive success and ultimately the year class strength of a species. Such factors produce considerable variation in adult population numbers, egg deposition and fry emergence, as was observed at the walleye spawning bed rehabilitation sites in the Whiteshell Provincial Park in the spring of 1987.

The lack of high precipitation and runoff reduced the chances of reproductive success at some of the study locations. Discharge is important to spawning success because in years of medium to high volume runoff, more walleye are found in the spawning run (Olson and Scidmore 1962). Lower flows in 1987 as compared to 1986, particularly at Falcon and Hamilton's creeks, may have discouraged walleye from migrating upstream. A total of only 116 female walleye were reported to have moved into Falcon Creek in 1987 (Manitoba Fish Culture records). In 1986 however, upstream female migration numbered 456. Low water level and flow on Falcon Creek resulted in numerous obstructions for upstream moving migrants. The culvert at Fairway Crescent, previously replaced, was again seen as an obstruction providing inadequate water depth to allow walleye passage. The formation of a drop-off on the downstream side of the culvert became an obstruction as discharges declined. There were, however, dense concentrations of white suckers below the culvert and reported sightings of suckers upstream of the culvert.

It is believed that few walleye migrated into Falcon Creek, Hamilton Creek and Rennie River to spawn in 1987 than would have

occurred in a normal run-off year. This resulted in only a few eggs and larvae being collected. Consequently, concluding a low utilization of stream habitat for spawning based on these results may not be an accurate appraisal for these walleye populations.

The rapid recession of flows after spring peak discharge on Hamilton's Creek, Falcon Creek and Rennie River, resulted in relatively low flows late in the spawning run and incubation period. Water depths and velocities over the artificial substrate beds (late April - early May) were between: 13.1-52.0cm/0.03-0.885m/sec, 8.0-42.0cm/0.07-0.181 m/sec and 30.0-64.0cm/0.13-0.341m/sec, respectively for each location. Various sources indicate a preference for water depths in spawning areas of less than 1.5 m, and probability of-use curves shown in Gaboury (1985) indicates a strong preference for water depths of 0.45 - 0.9 m and preferred water velocities for spawning of 0.6 - 1.1m/sec. These criteria were met early in the spawning run but, as discussed previously, the rapid attenuation of flow after spring peak discharge soon reduced preferred spawning and incubation conditions to sub-optimal.

Ultimately these same low flows retard the passive dispersal of larvae to suitable nursery habitat. At Hamilton's Creek, water level by the end of the sampling period, allowed enough depth to submerge only the front end (15 cm) of the cone of a larval drift trap. This is clearly illustrated in Table 5 where the percentage of flow sampled is as high as 10%.

Shallow water depths had a negative effect on the provision of holding zones. The importance of these zones and their proximity to the spawning beds were considered to be of great importance by Gibson and

Hughes (1977). Both day and evening observations at Falcon and Hamilton's Creek revealed very few areas where water depth would actually permit fish to hold. One adult walleye was actually pulled from the rocks at spot check Site #4 in Hamilton's Creek on May 1 where it had become stranded due to insufficient water depth. In the few areas available, fish density was high. Ocassionally, between seven and twelve fish, suckers and walleye, would occupy a pool approximately one meter long, 50 cm wide and 30 cm deep. Therefore, even with the provision of a preferred cobble substrate, the rapid attenuation of flow immediately after spring peak discharge prevented utilization of much of the area by spawning walleye. This problem could be observed particularly well at Hamilton's Creek early in May where in sections of the spawning cobble, incubating walleye eggs and holding zone pools became de-watered.

Competition for spawning space can also contribute to lower recruitment rates. Both white sucker and walleye have similar preferences for spawning habitat (Scott and Crossman 1973) and white suckers have been documented to prey upon walleye eggs (Wolfert et al. 1975). Competitive forces would have additionally been intensified in areas of high sucker concentrations, caused by low water levels. Observations showed that white sucker numbers were frequently higher on the artificially placed cobble when compared to adjacent areas, and egg abundance for each sample site clearly illustrates just how prolific the species is.

Statistical analysis of this spring's egg sampling results illustrated that a much higher walleye egg viability was achieved on coarse substrates as compared to silt/soil material. Sedimentation

occurs predominately in the slower moving waters and its accumulation can cover suitable spawning substrates preventing water percolation through the cobble material, suffocating incubating fish eggs (Colby et al. 1979; Machniak 1975). Egg survival is therefore higher on gravel and cobble substrates than on muck or sand (Johnson 1961). Similarly, Gibson and Hughes (1977) obtained a walleye egg survival rate of 37% on gravel and only 3.6% on sand substrates in Hamilton's Creek.

Sedimentation and decomposition on the bottom interfere with gas exchange and oxygen supply. In areas with coarse substrates, eggs settle in the interstitial spaces between cobbles. If these spaces are filled with organic material, the eggs can be destroyed by decomposition products. Colby and Smith (1967) found that oxygen concentrations drop to low levels very near the mud-water interface and that hydrogen sulphide concentrations are high over wood-fibre sludge deposits which were common at all areas adjacent to the artificially enhanced spawning beds at Rennie River and Red Rock Lake locations. Also, due to the low discharges in 1987 much of the organic material among the spawning substrates in Hamilton's Creek, Falcon Creek and Rennie River was not flushed out by the spring freshet.

Flow regulation at Rainbow Falls during the spawning/ incubation period this spring was relatively constant without large peak discharges, as compared to previous years (1984, 1985), preventing eggs from being resuspended in the water column and washed downstream into marginal habitat areas. Flow regulation improved incubation conditions in 1987, yielding a greater number of larval walleye in 1987 (22) than in 1985 (4).

At Red Rock Lake, no walleye were observed on the spawning

ground and only 32 non-viable walleye eggs were found, most likely washed ashore by wave action. Eschmeyer (1950), Johnson (1961), Regier et al. (1969) and Priegel (1970) also reported walleye egg mortality after being washed ashore. Poor results at Red Rock Lake could be due to a small spawning population or because the artificial spawning reef was not placed in an historic spawning location.

In summary, the particular requirements of successful spawning and embryonic development from the egg to fry stages requires: the absence of barriers to upstream movement, spawning areas usually in riffles with a substrate of stable cobble relatively free of sediment, a pool-riffle ratio that provides spawning area and escape cover in close proximity, and a sustained flow of well oxygenated water through the spawning gravel. These prescribed guidelines will help to ensure that there is actual habitat improvement rather than habitat alteration.

Environmental conditions and water parameters have a critical effect on larval development, growth, behavior and survival. Fish larvae are ecologically distinct organisms and low discharge or even dewatering, as observed at Rennie River and Falcon and Hamilton's creeks, not only destroys critical spawning and larval fish habitat but increases competition for any suitable habitat that remains. Therefore, to ensure the survival and well being of specific populations, significant loss or alteration of larval habitat must be prevented because fish larvae must be produced and survive in significant numbers to sustain their respective adult populations.

Because of the complex nature of these streams, enhancement projects can never be totally predictable. Therefore, it is valuable to

evaluate each project. To do this effectively, studies should span several years having different environmental conditions. This information will assist in planning and designing future improvements.

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LITERATURE CITED

Auer, N. A. (ed.). 1982. Identification of Larval Fishes of the Great Lakes Basin with Emphasis on Lake Michigan Drainage. Great Lakes Fishery Commission, Ann Arbor, Michigan. Special Publication 82-3, 746 pp.

Burton, W., and J. F. Flannagan. 1976. An Improved River Drift Sampler. Canada Fisheries and Marine Service Technical Report 641.

Colby, P. J. & L. L. Smith. 1967. Survival of Walleye Eggs and Fry on Paper Fiber Sludge Deposits in Rainy River. Minnesota. Trans. Am. Fish. Soc., 96 (3) : 278-296.

Colby, P. J., R. E. McNichol & R. A. Ryder. 1979. Synopsis of Biological Data on the Walleye (Stizostedion vitreum vitreum). Food and Agricultural Organization of the U. N., Rome. 139 pp.

Eschmeyer, P. H. 1950. The Life History of the Walleye, (Stizostedion vitreum) (Mitchill) in Michigan. Mich. Dept. Conserv., Inst. Fish. Res. Bull. No. 3, 99 pp.

Gaboury, M. N. 1985. A Fisheries Survey of the Valley River, Manitoba, with Particular Reference to Walleye (Stizostedion vitreum) Reproductive Success. Man. Dept. Nat. Res. Fisheries MS Report No. 85-02, 149 pp.

Gibson, R. J. and C. E. Hughes. 1977. A Walleye Stream Spawning Study on Hamilton's Creek. 1969. Man. Dept. Nat. Res., Fish Br. MS Rep. No. 77-31, 57 pp.

Johnson, F. H. 1961. Walleye Egg Survival on Several Bottom Types in Lake Winnibigoshish Minnesota and Connecting Waters. Trans. Amer. Fish Soc., 90 : 312-322.

Li, S., and J. A. Mathias. 1983. Cases of High Mortality Among Cultured Larval Walleye. Trans. Amer. Fish. Soc. 111 : 710-721.

Machniak, K. 1975. The Effects of Hydroelectric Development on the Biology of Northern Fishes, III Yellow Walleye, A Literature Review and Bibliography. Can. Dept. Env., Fish. Mar. Serv., Tech. Rep. No. 529.

McGarry, T. 1985. Water Requirements for Walleye on the Whiteshell and Rennie Rivers. Manitoba Department of Natural Resources Bulletin. 81 pp.

Moenig, J. T., M. Morelli, B. Bayer and D. A. Williamson. 1978. A Limnological Investigation of Falcon Lake, Manitoba, 1974-75 with Emphasis on Local Water Quality Changes. Man. Dept. Nat. Res., Whiteshell Study Tech. Doc. No. 1.

Nelson, W. R. 1968. Embryo and Larval Characteristics of Sauger, Walleye and their Reciprocal Hybrids. Trans. Am. Fish. Soc. 97 (2) : 167-174.

Olson, D. E. and W. J. Scidmore. 1962. Homing Behavior of Spawning Walleyes. Trans. Amer. Fish. Soc. 91 (4) : 355-361.

Ontario Ministry of Natural Resources. No date. Community Fisheries Involvement program; Field Manual. Toronto, Ontario.

Priegel, G. R. 1970. Reproductive and Early Life History of the Walleye in the Lake Winnebago Region. Tech. Bull. Wisc. Dep. Nat. Resour., (45) : 105 pp.

Regier, H. A., V. C. Applegate and R. A. Ryder. 1969. The Ecology and Management of the Walleye in Western Lake Erie. Tech. Rep. Great Lakes Fish. Comm., (15) : 101 pp.

Scott, W. B. and E. J. Crossman. 1973. Freshwater Fishes of Canada. Fish. Res. Bd. Can., Bull. No. 184, 966 pp.

Wolfert, D. R., W.-D. N. Busch and C. T. Baker. 1975. Predation by Fish on Walleye Eggs on a Spawning Reef in Western Lake Erie, 1969-71. Ohio J. Sci., 75 (3) : 118-125.

Zarr, Jerrdd. H. 1984. Biostatistical Analysis, 2nd edition. Dept. of Bio. Scn., N. Illinois University, Prentice-Hall, INC., 673 pp.

Appendix 1. Water temperatures (°C) in Falcon Creek from May 8/87 to May 21/87 approximately 50 meters downstream of Fairway Crescent culvert.

Date	Minimum	Maximum
May 8	16.0	18.6
May 9	15.0	16.8
May 10	14.6	15.4
May 11	14.6	15.6
May 12	12.8	15.8
May 13	13.2	15.2
May 14	14.0	15.8
May 15	13.8	16.4
May 16	14.6	16.6
May 17	15.4	17.4
May 18	14.2	15.6
May 19	13.0	14.2
May 20	11.2	13.4
May 21	10.8	11.4

Appendix 2. Water temperatures (°C) in Hamilton's Creek approximately 20 meters downstream of artificial substrate and study site.

Date	Minimum	Maximum	Date	Minimum	Maximum
April 8	7.2	9.6	May 1	9.8	13.7
April 9	6.7	7.3	May 2	9.0	13.8
April 10	6.8	7.5	May 3	10.0	13.7
April 11	6.8	7.5	May 4	10.5	15.0
April 12	6.9	7.8	May 5	13.9	19.0
April 13	7.3	8.0	May 6	12.5	15.2
April 14	7.4	8.4	May 7	11.3	17.0
April 15	7.6	9.2	May 8	11.5	18.6
April 16	7.8	8.2	May 9	12.8	16.2
April 17	8.0	9.6	May 10	11.5	14.6
April 18	9.0	12.8	May 11	11.0	15.2
April 19	11.0	13.4	May 12	11.2	17.0
April 20	8.1	11.2	May 13	14.0	17.4
April 21	8.4	10.5	May 14	12.6	16.4
April 22	10.0	11.6	May 15	12.1	19.4
April 23	9.6	11.9	May 16	14.8	18.8
April 24	10.0	12.6	May 17	12.6	14.8
April 25	11.2	13.4	May 18	10.6	14.2
April 26	10.9	13.8	May 19	12.6	14.2
April 27	11.0	14.5	May 20	12.4	13.2
April 28	11.2	15.5	May 21	11.0	13.0
April 29	10.4	13.9			
April 30	8.8	11.2			

Appendix 3. Water temperatures (°C) in Rennie River (Site #2) approximately 20 meters downstream of enhancement study site.

Date	Minimum	Maximum	Date	Minimum	Maximum
April 8	6.0	6.8	May 1	12.8	14.0
April 9	5.9	7.2	May 2	13.5	14.4
April 10	6.5	7.4	May 3	14.4	15.2
April 11	6.8	7.6	May 4	15.2	16.4
April 12	6.8	7.0	May 5	16.4	17.4
April 13	6.8	7.8	May 6	16.2	16.8
April 14	6.8	8.6	May 7	15.8	16.6
April 15	8.0	9.6	May 8	16.0	18.6
April 16	9.0	9.4	May 9	17.0	18.6
April 17	9.2	10.2	May 10	16.6	17.4
April 18	10.1	13.2	May 11	16.0	17.4
April 19	13.2	14.6	May 12	15.8	17.0
April 20	10.6	13.8	May 13	17.0	17.8
April 21	10.6	11.4	May 14	16.8	17.6
April 22	11.1	12.4	May 15	16.6	18.6
April 23	11.6	12.8	May 16	17.8	18.6
April 24	11.6	12.2	May 17	16.8	18.0
April 25	12.2	13.2	May 18	15.6	17.0
April 26	12.8	13.4	May 19	16.4	17.0
April 27	13.0	13.8	May 20	15.9	16.6
April 28	13.0	14.2	May 21	14.6	16.0
April 29	13.2	14.0			
April 30	12.6	13.1			